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# FOUNDATIONS OF THE MODERN THEORY OF CONTINUOUS MEDIUM THERMOMECHANICS

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**Abstract.** The essential antinomies and limitations of the traditional model of the motion of continual media in certain aggregative states are formulated. The physical bases, partly on the phenomenological concepts, and the mathematical formalism of the innovative concept of describing the thermomechanics of such media are outlined. The required field functions are fundamental substances: density, amount of movement, increment of internal energy, - as well as direct rotation of the labeled elementary part of the medium per unit of time. The practical significance of the theory under development is underlined. The theme and content of the work are such that it should be considered in the discussion plan. Some easy accesses examples of calculations in simplified formulation are given.

**Keywords**: continuous medium, fluid, thermomechanics, systems of counting, concerted action, deformations, collapse passage.

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## 1 Introduction

Multifunctional servers, impressive levels of speed and RAM of modern computer equipment, as well as prospects for their further development, along with the continuous improvement of methods, tools and technologies for precision physical experiments, contributing to the formation of moderate but sustained optimism with the statement of the possibilities in the not too distant future, to solve scientific and technical problems of almost any degree of complexity.

This class of tasks includes, in particular, creative design solutions and in-depth studies of thermomechanical processes in the active sectors of the main power units of TPPs, NPPs, HPPs, as well as in other non-ordinary energy facilities for various purposes and in other artifact and natural systems in all their diversity. The expected initial measures, including both ensuring the highest qualities with dynamic stability of their creation, and the achievement of guaranteed extreme thermomechanical indicators of the executive bodies of power devices corresponding to objects in a wide range of deviations from the nominal condition.

A rational way of possible satisfaction of the marked majorant estimates of the effective qualities of the research is to attract the most perfect spatial-temporal, i.e. four-dimensional 3Dt (or 4D), statements in the description of movements and transformations of working fluids that are in different aggregative states.

We believe that the 3Dt physical and mathematical model of non-equilibrium thermomechanics of solid, liquid and gaseous continuous media presented below and developed from unified installations will prove to be directly demanded over time in a phased advance to the previously noted objectives.

An additional application of the following concept, which is quite significant at the current time, consists of the following. The desired, most competitive results in the subject area of research considered here can, to a certain extent and, of course, at the level of predictions, be achieved by attracting / borrowing ready-made software products of simulation computer reproduction of the discussed phenomena based on traditional physical and mathematical models of their description. This approach, widely used today, implies the ability of the user to competently form preferences when comparing different versions of such computer services. In this regard, one of the determining reasons, which led the author to this publication, was also a reinforced opinion that familiarization with the foundations of the proposed alternative theory would help the developer of innovative objects and systems of various applications, which is a consumer of existing thermomechanical calculation programs, find it easier to navigate in the ever-increasing list relevant proposals and implement the most favorable of them.

An extended understanding of the essence of the developed scientific product and the details of individual transformations, including designations, are presented in the author's previous works on this topic see references. We hope that the interested specialist, taking into account the singular complexity of the subject of study, will condescendingly refer to individual points of our previous works, which subsequently required a certain clarifying correction and a demanded generalization of the initially obtained relations.

The undertaken research, the main results of which in a compact form are set forth below, seems to be consistent, but at the same time it essentially goes beyond the framework of well-established ideas about the physical and mathematical description of continuous dynamics, including fluids, media (C-mediums and F-mediums enumeration). Further concretization of the present unified, abstractly independent of the type of aggregative state of the environment, the formalism requires large-scale and, as a rule, precision field experiments to verify the group of additional physical coefficients included in the proposed paradigm.

The statements of the corresponding initial-boundary-value problems turn out to be fundamentally incorrect, especially for F-mediums under turbulent flow regimes, and involving the introduction of certain agreements in the concept of a generalized solution of such problems using, inter alia, and possibly the *ergodic* hypothesis of statistical physics (Morgunov, 2015a), (Layfer, 1954), (Dryden, 1959), (Barnes & Coker, 1905).

Note that thermomechanical processes are considered primarily in the framework of the installations adopted in Morgunov (2015a), which is assumed *to be known*.

Direct numerical implementation of the developed model, without truncations, filtering and subgrid approximations, even for the simplest canonical areas of medium movement, will be possible only with the help of hyper computer engineering.

These difficulties are significant, but the intellectual and material costs required to overcome them are justified by the undeniable imperative to further improve the methods of analysis and synthesis of the super-complex, but ubiquitous systems considered here.

Let us dwell on the following preliminary, but fundamentally significant circumstances.

- The prevailing part of the limitations specified in the main section of the article, or the complementarity violations in the usual models of C- mediums dynamics, for many years seemed to the author as an unnatural reality. Almost three centuries of invaluable scientific and practical experience in the study of C- mediums thermomechanics predetermined the manifestation of a kind of *"inhibition syndrome"* in the final decision to popularize the concept presented below.

- The outlined paradigm, eliminating (to put it mildly - in many ways) existing antinomies, in relation to modeling the functions of external surface action (see the left parts of equations (I) - (IV) in the second column of the table) remains fundamentally phenomenological. Therefore, its further and thorough theoretical and experimental approbation is required.

- The text should strictly distinguish between the subtle designations of the coordinates $x_k(t),\ k = 1,3$ and the only absolute argument, namely, time $t$, the motion of the *labeled* elementary medium particle (*e.m.p.*) for the tracking / trajectory / Lagrangian frame of reference: *L-systems*, in the *right-hand* sides of equations (I) - (IV) and denoted in the *left-hand* parts of these equations by *thickened* font of the notation for the coordinates $\mathbf{x}_k$ and time $\boldsymbol{t}$ of the rigid / Eulerian reference system, then the *E-system*, for establishing *3Dt* distributions of action functions with four independent arguments. Thus, in the *L-system* $\vec{x}(t)$ there is the current position of the point belonging to the labeled particle of the medium, and in the *E-system* the radius vector $\overrightarrow{\mathbf{x}}-$ is the point marker of the timeless *3D* space. Prototypes of labeled *e.m.p.* are passing relatively of such points discretely distributed on the regular net of *E-system* of space. It is clear that at each fixed point in time these vectors coincide.
- It is easy to see that the classical foundations of the C-mediums science sections "Continuous kinematics" and "Basic equations of the dynamics of an ideal incompressible fluid" (Euler, Bernoulli) are naturally preserved if for the first section the corresponding distributions of field functions are considered in the *E-system* $\overrightarrow{\mathbf{x}}$ each "frozen" time point $\boldsymbol{t}$, or at each *abstract* point $\overrightarrow{\mathbf{x}}-$ with variable $\boldsymbol{t}$, and for the second section - in $L\Lambda E$ - reference systems.
- The desired functions of the substance-field are substances $\rho, \vec{v}, \varepsilon, \vec{\Lambda}$ (see explanations below).

# 2 Main part

For a clearer justification of the dependencies described below, in Fig.1a,b the topological properties of the $L\Lambda E$ - systems are shown conditionally and separately, and in Fig.1c, when they are combined. The shaded arrows in Fig.1a, departing from the arrow of time $t$ and ending on the

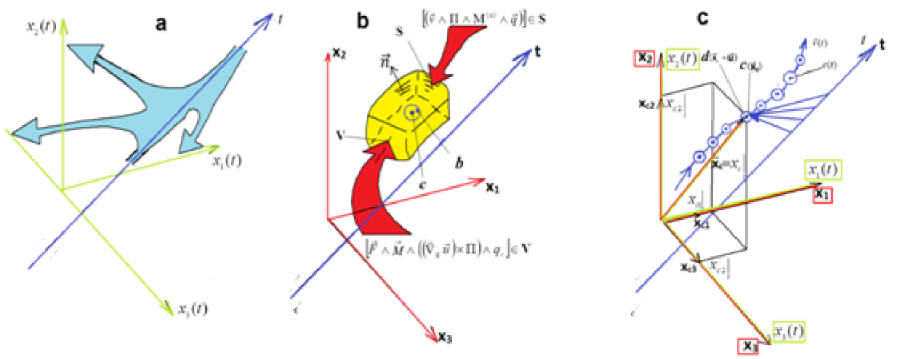

Figure 1: Schematic representations of $L\Lambda E$ - systems: a, b- separate; c - combined

axes of the tracking / Lagrangian frame of reference, emphasize figuratively the dependence of the Cartesian coordinates of each physical point (PP, see below) of the medium on this absolute argument. As before Morgunov (2015a), PP means the smallest material formation, for which the *continuity* hypotheses and *non-equilibrium* thermodynamics processes is still valid.

Externally similar coordinate system in Fig.1b is timeless in space with four, as previously indicated, independent arguments. It also shows a simply connected, otherwise *arbitrary*, but fixed in *3D* small macrovolume $\overline{\mathbf{v}}$ with boundary $\mathbf{s}$ and orth of the external normal to it $\vec{n}$, filled with a single-phase moving medium. At the same time $\bar{\mathbf{v}} \in \bar{\mathbf{V}}$, with the norm $\|\bar{\mathbf{v}}\| << \|\bar{\mathbf{V}}\|$, where $\bar{\mathbf{V}}$ - is the closed calculated macro-region of studying the motion of the C-medium. Inside $\mathbf{v}$ for a given time instant $\boldsymbol{t}$, the instantaneous position of a labeled elementary particle with a focus $\mathbf{c}$ and a some virtual point in it $\mathbf{b} \in \overline{\mathbf{v}}$ is highlighted. Two darkened silhouette arrows show and identify external volumetric and surface actions on $\overline{\mathbf{v}} = \mathbf{v} \cup \mathbf{s}$ of different physical nature.

In Fig.1c additionally depicts a fragment of the trajectory of the focus $\mathbf{c}$ of the *pre-images* of the past (the upper part of the trajectory) and the future (lower part of the trajectory) of the labeled particle. Strictly speaking, the points $\mathbf{c}\Lambda\mathbf{b}$ introduced here are possible / virtual PP of the selected medium particle and in the final dynamic equations, with the exception of the right side of equation (IV) (see below), their specific positions are *leveled*.

Now, giving preference to the compressed style of presentation of the material, we proceed as follows. We introduce a table consisting of two columns. In the left column we place the well-known and characteristic closed system of equations of the dynamics of the C-medium (It) - (IVt), (1t) - (3t), which, in particular, for F-mediums is described in [5]. At the bottom of this column we list the undeniable antinomies and limitations of this system.

In the second - right column we place the innovative system of fundamental equations of C – medums (I) - (IV) with extremely concise detail (1) - (6), (A), (B), (C) of separate fragments of the fundamental equations indicated by Roman in numbers. Next will follow the necessary explanations, comments and conclusions from the range of issues under consideration. The descriptions of random / pseudo-random exposures and, in general, aspects of setting initial-boundary conditions are omitted here. Variants of the formalization of these factors are described in works Dryden (1959), Morgunov (2015b), mainly in the aspect of pro-domains.

So, taking into account the presence in the future text of an explanation of the notation (see also the list of notation in the forerunner work Morgunov (2015a)), we have the following.

**Fundamental and private laws/equations of the continuous mediums thermomechanics** (without regard of random perturbations and boundary 3Dt conditions)

| Traditional | Alternative |
|---|---|
| $\leftarrow E \rightarrow$ system | $E - system \leftarrow \vert \rightarrow L - system : \begin{bmatrix} cause \\ action \end{bmatrix} \begin{matrix} \rightarrow \\ \leftarrow \end{matrix} \begin{bmatrix} effect \\ consequence \end{bmatrix}$ |
| $-\rho\vec{\nabla}_{\vec{\mathbf{x}}} \cdot \vec{v} = \frac{d\rho}{d\,\mathbf{t}}$ (I**t** ) | $-\vec{\nabla}_{\vec{\mathbf{x}}} \cdot \vec{v} = \frac{d\ln\rho}{d\,\mathbf{t}}$ (I) |
| $\rho\vec{F} + \vec{\nabla}_{\vec{x}} \cdot \mathbf{P} = \rho\frac{d\vec{v}}{d\mathbf{t}}$ (II**t**) | $\rho\vec{F} + \vec{\nabla}_{\vec{x}} \cdot \mathbf{\Pi} = \frac{d\rho}{dt}$ (II)<br>$ubi\ \mathbf{\Pi} = \mathbf{P}^{(s)} + \mathbf{P}^{(a)},\ \mathbf{P}^{(s)} = \mathbf{P}_s + \mathbf{P}_d,\ et\ \mathbf{\Pi}_d = \mathbf{P}_d + \mathbf{P}^{(a)}$ |
| $\mathbf{P} \cdot \cdot \dot{\mathbf{S}} + \rho q_{cd} = \rho\frac{d\varepsilon}{d\mathbf{t}}$ (III**t** ) | $\mathbf{\Pi} \cdot \cdot (\vec{\nabla}_{\vec{\mathbf{x}}}\vec{v}) + [(\vec{\nabla}_{\vec{x}}\vec{u}_d)^* \times \mathbf{\Pi} + \vec{\nabla}_{\vec{\mathbf{x}}} \cdot \mathbf{M}^{(a)}] \cdot \vec{\Lambda} +$<br>$+\rho q_{cd} + \rho q_r = \frac{d\rho\varepsilon}{dt}$ (III) |
| $\mathbf{P} = \mathbf{P}^* = -\rho I + (2\mu\dot{\mathbf{S}}_d \vee 2G\mathbf{S}_d)$ (IV**t** ) | $(\vec{\nabla}_{\vec{\mathbf{x}}}\vec{u}_d)^* \times \mathbf{\Pi} + \vec{\nabla}_{\vec{\mathbf{x}}} \cdot \mathbf{M}^{(a)} = \frac{d\mathbf{J}\vec{\Lambda}}{dt}, \mathbf{J} = c_J æ_J^{-2}\rho$ (IV) |
| Joule:<br>$\varepsilon = \varepsilon_0 + \int_{T_0}^{T} c_V(T)dT$ (1**t**) | Inversions (1t) (see also (Layfer, 1954)):<br>$$T = T_0 + \int_{\varepsilon_0}^{\varepsilon} \beta_\rho(\rho, \varepsilon; \mu_\beta)d\varepsilon, \quad T_0 \geq T_{\inf}, \quad \beta_\rho = c_V^{-1} \qquad (1)$$ |
| Clapeyron. . . :<br>$\mathbf{F}(\rho,p,T) = 0$ (2**t**) | Strong form of Generalization (2t) (see also (Layfer, 1954)):<br>$$\mathbf{P}_s = -\left\{p_0 + \int_{\overset{\iota}{L}\rho_0, \overset{\iota}{L}\varepsilon_0}^{\overset{\iota}{L}\rho, \overset{\iota}{L}\varepsilon} \mu_b \left[\mathbf{k}\overset{\iota}{\overline{(\mathbf{t})B}}\vert_\varepsilon\, d\overset{\iota}{L}\rho + \mathbf{k}\overset{\iota}{\overline{(\mathbf{t})B}}\vert_\rho\, d\overset{\iota}{L}\varepsilon\right]\right\} I, \qquad (2)$$<br>$L = \ln,\ \ \dot{L} = \partial\ln/\partial\ t.\ \ \ddot{L} = \partial^2\ln/\partial\ \mathrm{t}^2 \ni l = \emptyset,\ ...$ |
| Fourier:<br>$\rho q_{cd} = -\rho\vec{\nabla}_{\vec{\mathbf{x}}} \cdot \vec{q}_{cd},$<br>$\vec{q}_{cd} = -\lambda\vec{\nabla}_{\vec{\mathbf{x}}}\,T$ (3t ) | Stress deviator $\mathbf{P}_d$ approximation (see also (Layfer, 1954))<br>$$\mathbf{P}_d = \mathbf{P}_{d0} + \overset{\iota}{G}(\rho, \varepsilon) \int_{\overset{\iota}{S}_{d0}}^{\overset{\iota}{S}_d} \frac{\iota}{\mathbf{K}(t) \cdot d\mathbf{S}_d} \qquad (3)$$<br>$\overset{\iota}{G} = \overset{\iota}{G}_0 + \int_{\overset{\iota}{D}\rho_0, \overset{\iota}{D}\varepsilon_0}^{\overset{\iota}{D}\rho, \overset{\iota}{D}\varepsilon} \overset{\iota}{\mu}_g \left[\overset{\iota}{\overline{\frac{\partial G}{\partial D\rho}dD\rho + \frac{\partial G}{\partial D\varepsilon}dD\varepsilon}}\right],$<br>$D = 1, \dot{D} = \partial/\partial\ t, \ddot{D} = \partial^2/\partial\ \mathbf{t}^2$ |

**Antinomies and Limitations**

A.1. Reduction (I $\mathbf{t}$ – IV $\mathbf{t}$) to one *E-system* of counting with non-conformity *action* of operators $\frac{d}{dt} \not\Leftrightarrow \frac{d}{dt} = \frac{\partial}{\partial t} + (\vec{v} \cdot \vec{\nabla}_{\vec{x}})$, in the second operator are *thickened designation of the arguments.*

A.2. When establishing (I$\mathbf{t}$ - IV$\mathbf{t}$) unlawfully introducing directly the operator $d/d\,t$ under the sign of the integral over the volume V($t$) (with a *fixed number* of particles of C-medium), as $V$ is changes in the time.

A.3. Relationships of Cause-and-Effect in the (I$\mathbf{t}$) - (IV$\mathbf{t}$) - are considered on item A.1. and under the *symmetric mechanics* of C-mediums with truncated quantity of kinematic tensors in the functions of actions.

A.4. Not figured functions of *action* the forces, moments and energies of *vortex fields* by virtue of presentation of *e.p.m.* turn as quasi-solid bodies or on basis of the hypothesis “plane section”, etc. for corresponding C-mediums.

A.5. Here been used global equilibrium thermodynamics (*utlex*).

A.6. Secondary / measured (*utlex* for F-mediums) variables $p \wedge T$ *given the status* of basic functions of state along with fundamental substances $\rho, \vec{v}, \varepsilon$.

A.7. There is no *direct* taking into account of the thermal factor in the fundamental substance $\vec{v}$.

A.8. No *physical* aspect of appearance of sporadic turbulent monofurcation in F-mediums.

A.9. Not revealed the *memory* of before the actual states of fields deformation and its velocity.

**Collapse-Functions (see lower also (C))**

$I < I^* : \overset{\iota}{\mathbf{k}} = 1,\ \ \overset{\iota}{\mathbf{K}} = \mathbf{I},$

$$I \geq I^* : \begin{cases} \overset{\iota}{\mathbf{k}} = \overset{\iota}{k}\,\mathbf{1}(\mathbf{t} - \mathbf{t}^*),\ \ 0 \leq \overset{\iota}{k} \leq 1, ... \\ \overset{\iota}{\mathbf{K}} = \mathbf{I}\,\overset{\iota}{K}\,\mathbf{1}(\mathbf{t} - \mathbf{t}^*),\ \ 0 \leq \overset{\iota}{K} < 1, .... \end{cases} \tag{4}$$

$I^*(\vec{\nabla}_{\vec{x}} \cdot \mathbf{a}_d)$- *solidus media / liber turbulences,*
$I^*(\vec{\nabla}_{\vec{x}} \cdot \mathbf{a}_d; Ix, \xi)$- *iunetus turbulences,*
$\vec{\nabla}_{\vec{x}} \cdot \mathbf{a}_d = \vec{\nabla}_{\vec{x}} \cdot \mathbf{a}$

**Direct Accounting of Thermal Factor in Momentum**

$$\vec{v} = \vec{v}_f + \vec{v}_q,\ \ \vec{v}_q = \mathcal{A}\vec{\nabla}_{\vec{\mathbf{x}} \vee \vec{x}} T(\rho, \varepsilon) \tag{5}$$

**Kinematic Tensors with Memory**

$$\begin{array}{l} \text{Short memory} \\ \dot{S}_{ij} \vee \dot{A}_{ij} = \frac{1}{2}\dot{Y}_i(a_{d.j}) + \vee - \frac{1}{2}\dot{Y}_j(a_{d.i}), \\ \text{Long memory} \\ S_{ij} \vee A_{ij} = \frac{1}{2}Y_i(a_{d.j}) + \vee - \frac{1}{2}Y_j(a_{d.i}), \\ \dot{Y}_i(\_) = \int\limits_0^t \frac{\partial \_}{\partial \mathbf{x}_i} d\tau, Y_i(\_) = \int\limits_0^t (\int\limits_0^{\leftarrow t} \frac{\partial \_}{\partial \mathbf{x}_i} d\tau) d\tau, \\ ad\ \vec{u}_{d.0} = \vec{v}_{d.0} = \vec{a}_{d.0} = 0,\ \ \vec{a}_d = \vec{a} - \vec{a}_c = \partial \vec{v}_d / \partial t \end{array} \tag{6}$$

**Operations with Antisymmetrics Tensors**

$$\mathbf{P}^{(a)} = \mathbf{P}_0^{(0)} + 2\,\overset{\iota}{R}(\rho, \varepsilon) \int\limits_{\overset{i}{A}_0}^{\overset{i}{A}} \overline{\overset{\iota}{\mathbf{K}}(t) \cdot d\mathbf{A}}\,,\ \ 2\vec{\nabla}_{\vec{x}} \cdot \overset{\iota}{\mathbf{A}} = \vec{\nabla}_{\vec{x}} \times \overset{\iota}{\vec{\mathbf{\Omega}}} \tag{A}$$

$\overset{i}{\vec{\mathbf{\Omega}}} = \vec{\nabla}_{\vec{x}} \times \overset{i}{\vec{w}},\ \ \vec{w} = \vec{u},\ \ \dot{\vec{w}} = \vec{v},\ \ \ddot{\vec{w}} = \vec{a}$

$\vec{\nabla}_{\vec{x}} \cdot \mathbf{M}^{(a)} = \vec{\nabla}_{\vec{x}} \cdot (\mathbf{M}_0^{(a)} + 2\,\overset{i}{N}(\rho, \varepsilon)] \int\limits_{\overset{i}{A}_0}^{\overset{i}{A}} \overline{\overset{\iota}{\mathbf{K}}(t) \cdot d\mathbf{A}}$

$Dim\ N = [N] = \frac{H \cdot m}{m^2},\ \iota = \emptyset.$

**Connections Between Dyads**

$$\left(\vec{\nabla}_{\vec{x}}\,\overset{i}{\vec{w}}_d\right) = \left(\vec{\nabla}_{\vec{x}}\,\overset{i}{\vec{w}}\right),\ \ edo\ \left(\vec{\nabla}_{\vec{x}}\,\overset{i}{\vec{w}}_c\right) = 0 \tag{B}$$

$\vec{w}_d = \overrightarrow{u}_d,\ \ \dot{\vec{w}}_d = \vec{v}_d,\ \ \ddot{\vec{w}}_d = \vec{a}_d \ni \left(\vec{\nabla}_{\vec{\mathbf{x}}}\vec{a}_d\right) = \left(\vec{\nabla}_{\vec{\mathbf{x}}}\vec{a}\right)$

**Criterion of the Collapse-Passage**

$$\vec{\nabla}_{\vec{x}} \cdot \mathbf{U}_d = \vec{\nabla}_{\vec{x}} \cdot \mathbf{U} = \int\limits_0^t \left(\int\limits_0^{\leftarrow t} \vec{\nabla}_{\vec{x}} \cdot \mathbf{a}\partial\tau\right)\partial\tau \tag{C}$$

$I = \bar{u}_d^{\bullet} = \left|\vec{\nabla}_{\vec{x}} \cdot \mathbf{U}\right|$

$I^* = (|\vec{u}_d^{\bullet}|\ \ I^* = (|\vec{u}_d^{\bullet}|\,æ_{s.\,\sup})^*\,,\ I > I^*,\ \ eo\ \overset{i}{\mathbf{K}}{}^2 < 3,\ \overset{i}{\mathbf{k}} < 1$

Here is some comments to the information in these two columns of the table.

In the upper part of the left column of the table, the balance equations are written for specific mass $\rho$ (I$\mathbf{t}$), momentum $\vec{v}$ (II$\mathbf{t}$), increments of internal energy $\varepsilon$ (III$\mathbf{t}$). The balance equation of the moment of momentum (IV$\mathbf{t}$) in the accepted here representation of the *radius vector* of the action of the moments of external forces and inertia forces in the *E-system*, namely in the form $\vec{\mathbf{x}}$ [5] (and not in the *L-system*, that is, in the form as $\vec{x}(t)$, since these moments are actually applied to the particle of the medium, and not to the abstract point of a rigid 3D space), it reduces to the condition of symmetry of the stress tensor $\mathbf{P}$ (see the first equality in the graph ($IVm$); the upper asterisk is a transposition sign).

The closure of the system (I$\mathbf{t}$) - (IV$\mathbf{t}$) is carried out by invoking generalizations to the 3D case of Hooke's law for solid media and the Newton hypothesis for fluids given by Navier (see the last equality in (IV$\mathbf{t}$)), as well as the private Joule thermodynamic laws (1$\mathbf{t}$), Fourier (3$\mathbf{t}$)

and Clapeyron equations (or its known generalizations) (2**t**), but related to the conditions of globally equilibrium thermal processes.

The system (I**t**) - (IV**t**), (1**t**) - (3**t**) of the formalization of the fundamental and specific laws of thermomechanics includes, in aggregate, the entire list of inconsistencies and truncations formulated in the lower part of the left column: (A.1 - A.9).

We now turn to the content of the right-hand column of the table, focusing primarily on the successively considered (from A.1 to A.9) aspects of the *full* or possible phenomenological approach, eliminating the shortcomings expressed in relation to the already agreed model in the proposed concept.

A.1 The fundamental equations (I) - (III) individual derivative in $t$, therefore in the *L-system* on quantum time $\partial\tau = \Delta t$ from the scalar function $\mathbf{f}$ or $\mathbf{f}$ as $k - th$ component of the vector field function is determined by the limit

$$\frac{d\mathbf{f}}{dt} == \lim_{\substack{\Delta t \to 0 \\ \Theta \in [t, t+\Delta t]}} \frac{\mathbf{f}(t+\Delta t, \vec{x}(t) + \vec{v}(\Theta)\Delta t) - \mathbf{f}(t, \vec{x}(t))}{\Delta t}, \tag{7}$$

where in the linear positing $\vec{v}(\Theta) = 0,5(\vec{v}(t+\Delta t) + \vec{v}(t))$, $\vec{v}(t) = \vec{v}(t,\mathbf{x})$, $\vec{x}(t) = \vec{\mathbf{x}}$ (see too further indications (11), (12)).

For scalar functions $\mathbf{f}$ limit transitions are carried out directly, and for vector - for each of their components. In steady-state conditions the limit (7) adopts the repeating meanings. When the particles moves with constant field functions along a rectilinear coordinates of the inertial system of counting that $\frac{d\mathbf{f}}{dt} \equiv 0$.

Expression (7) is established changing $\mathbf{f}$ on time at motion of the marked *e.p.m.* along *their trajectory* on the specified step $\partial\tau$ and is differed on principle from the total derivative by $\mathbf{f}$ to $\mathbf{t}$in the *E-system* of counting, which is written in the form

$$\frac{d\,\mathbf{f}}{dt} = \lim_{\Delta t \to 0, \vec{x}} \frac{f(t+\Delta t, \vec{x}) - f(t-\Delta t, \vec{x})}{2\Delta t} + v_i \lim_{t, \Delta\vec{x} \to 0} \frac{f(t, x_i + \Delta x_i) - f(t, x_i - \Delta x_i)}{2\Delta x_i}. \tag{8}$$

Here the summation to $i = \overline{1,3}$, $d\vec{\mathbf{x}} \neq \vec{v}(t)dt$.

Strictly speaking, its not exists a derivative concept of the same independent argument by other, for example, $d\mathbf{x}_i/dt$ without explanation of its differentials ratio meaning.

Differences between the limits (7) and (8) are obvious.

We would notice that in preparing on perspective of algorithm for computer realization of the present conception differential / scale on time $\partial\tau = \partial\tau$ is fixed over ability to be solved of the proper / actual discrete of a frequency spectrum. Further, by each rated $\tau$ moment of time $\mathbf{t} + \partial\tau$ the *left* parts of the fundamental equations (I)-(III) are determined on the *regular* net of *E-system* of counting for *preceding* rated moment $\boldsymbol{t}$ including, naturally, *given* initial distributions of action functions at $\mathbf{t} = 0^+$ (see too before explanations for formalism (7)).

Effects of a operator $\frac{d}{dt}$ (L-system) application to functions $\mathbf{f}$ and its future transformation is considered in staging plan of concluding subjection of present work, noted by single asterisk * from the left.

A.2. In the original integral form of recording balance laws, an *arbitrarily* chosen macro-volume $\overline{\mathbf{v}}$ =$\mathbf{v}\cup\mathbf{s}$ is assumed to be fixed in the *E-frame* with a *certain* possibility of introducing a time differentiation operation under the sign of the integral over this volume for the corresponding field substance. As a result, we arrive at differential forms of laws (I) - (IV) with left and right sides that have a clear physical interpretation, but do not coincide with the similarly located terms in equations (It) - (IVt). Note that in equation (III), the expressions for the second arrival in the medium particle of conductive $q_{cd}$ and radiant $q_r$ types of energy are stored according to the traditional model of their description (see for example (Morgunov, 2015a), (Dryden, 1959), (Morgunov, 2017b)).

AA.3-4. The extension of the model to the class of *asymmetric* mechanics of C-media is associated with two circumstances.

a) A natural idea that rotations / torsion — rotations of elementary (up to the PP scale) particles of the medium occur, as well as shear deformations, according to the laws of deformable / changing volume and shape, as well as heat-conducting bodies is taken.

b) Following the logic of the analysis, the moments from inertial and external forces (bulk, surface) are considered on the radius-vector $\vec{x}_b(t)$ of some virtual point $b$ of the current e.m.p. (Fig. 2; see also Fig. 1 b, c). In fig. 2: indices $c \wedge b$ with $b$ in the notation refer to some center / focus $c$ and a virtual point of this particle $\mathbf{b}$ with a distance vector between them $\delta \overrightarrow{x}_{cb}$, which includes the component of *complete* deformation with velocity $\overrightarrow{v}_d(t, \overrightarrow{x}_b(t))$, i.e. from torsion and shear.

Vector $\vec{\Lambda}(t)$ of inertial second rotation e.m.p. (see equation IV in the Table, and Fig.2) belongs to the class of vortices of the total strain rate, i.e. $\vec{\Lambda}(t) \in \{\dot{\vec{\Phi}}\}$ and, accordingly, $\iota = \bullet$.

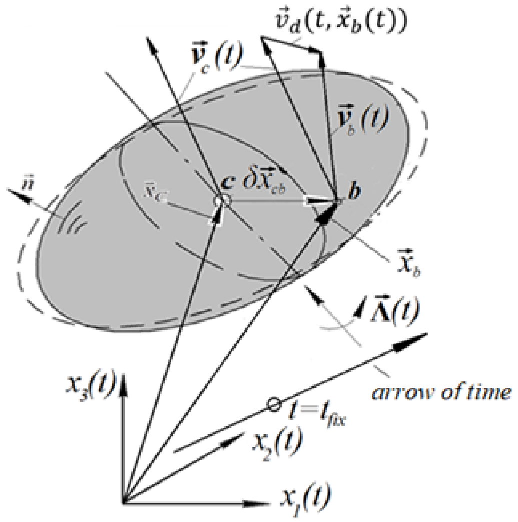


Figure 2: The instantaneous position of the labelled/marked particles of the medium. Actually particle - darkened volume; distortions: shear - bar loop, torsion - bar-dotted axis to the vector of the vortex $\vec{\Lambda}$ of inertial turning of marked e.p.m. for the unit of time

These factors have resulted in the introduction of the *complete* stress tensor $\mathbf{\Pi}$ and it deviator $\mathbf{\Pi}_d$ representation $\mathbf{\Pi}$ as the sum of symmetric $\mathbf{P}^{(s)}$ and antisymmetric $\mathbf{P}^{(a)}$ parts, followed by decomposition $\mathbf{P}^{(s)}$ into spherical $\mathbf{P}_s$ and deviator $\mathbf{P}_d$ terms. Tensors $\mathbf{P}_s$,$\mathbf{P}_d$ and $\mathbf{P}^{(a)}$, in turn, based on the phenomenological assumptions linearly expressed in terms of the unit tensor $\mathbf{I}$, as well as *symmetric* $\overset{\iota}{\mathbf{S}}/\underset{d}{\overset{\iota}{\mathbf{S}}}$ and antisymmetric $\overset{\iota}{\mathbf{A}}$ tensors of proper deformations and turns, as well as the speed and "acceleration" of data movements (see (2), (3), (A)). Recall still that the upper index *iota* identifies the top signs $\iota = \emptyset, \bullet, \bullet\bullet = \bullet, \bullet\bullet$.

For C-mediums with heterogeneous and non-isotropy of the intrinsic physical properties modules $\overset{\iota}{B}, \overset{\iota}{G}$, $\overset{\iota}{R}$, $\overset{\iota}{N}$ are suggested in the form of tensors scalar/tensor multiplied on proper kinematic tensors $\mathbf{I}, \overset{i}{\mathbf{S}}_d, \overset{i}{\mathbf{A}}$.

Let us remark absence in the equality (2), as consequence of notations simplification, of the terms

$$(2\,\overset{\iota}{G}\,`\int\limits_{\underset{s.1.0}{\overset{\iota}{I}}}^{\underset{s.1}{\overset{\iota}{I}}} \mathbf{k}`\overline{d\overset{\iota}{I}_{s.1}})\;\mathbf{I},\;\; \textit{summing up}\;\; \iota,$$

where $\overset{\iota}{I}_{s.1}$ are first invariant of tensors $\overset{\iota}{\mathbf{S}}$ $\overset{\iota}{G}$' and $\overset{\iota}{\mathbf{k}}$' are modules of viscosity and collapse-functions. These terms are taken into account a viscous resistance to high-speed change of particle medium volume.

For C-mediums with heterogeneous and non-isotropy proper physical properties modules $\overset{\iota}{B}, \overset{\iota}{G}, \overset{\iota}{R}, \overset{\iota}{N}$ represents in the form of tensors scalar multiplied on the corresponding tensors $\mathbf{I}, \overset{i}{\mathbf{S}}_d, \overset{i}{\mathbf{A}}$.

It proved also necessity entering into the formalism of *asymmetrical* mechanics C-mediums in the capacity of additional function of the action of the components of the antisymmetric tensor moments $\mathbf{M}^{(a)}\left[\frac{\mathrm{N\ m}}{\mathrm{m}^2}\right]$ from volume action of the surface of couple forces, applied to these particles from the *outside*. This tensor is expressed linearly in terms of tensors $\overset{\iota}{\mathbf{A}}$, and consequently - the vortex vectors $\overset{\iota}{\vec{\mathbf{\Omega}}}$ of the rotation, of its speed and acceleration with respect to instantaneous axes passing through the point $\mathbf{c}$ (see Fig. 2).

Noted in three previous item vector and tensor functions are, of course, in the right column of the table and figured in left part of the fundamental equations (II) - (IV). Operations with tensors $\overset{\iota}{\mathbf{A}}$ and vectors $\overset{\iota}{\vec{\mathbf{\Omega}}}$ are provided here in the form of (A) with the additional conditions (B). Modules $\overset{\iota}{R}(\rho,\varepsilon)$ and $\overset{\iota}{N}(\rho,\varepsilon)$ required initial verification. Recall that a colon in the first term of the equation (III) to the left means the corresponding double scalar multiplication of tensor on dyad. This additive/member is action of power of the inner (by volume) forces on velocity of energy $\varepsilon$ by change per unit time.

The first term in the left side of the moment balance equation (IV), written as a vector multiplication of the transposed dyad in the form of derivative of the vector deformation $\vec{u}_d$ on the radius-vector $\vec{\mathbf{x}}$, i. e. $\frac{d\vec{u}_d}{d\vec{\mathbf{x}}}$, on a full stress tensor $\mathbf{\Pi}$, there is arises in torsional deformation moment of imbalance on the external surface forces $(\vec{n}\cdot\mathbf{\Pi})$ (see (Ekman, 1911, pp.62-63)).

A. 5-6. As in earlier publications Morgunov (2015a), Dryden (1959) in this paradigm is used a hypothesis only about *local* thermodynamic quasi-equilibrium (LTD QE, see e.g. (Loitsyanskii, 1978)), i.e. on the 3D scale PP. Under this approach a functions of pressure $p$ and temperature $T$, viewed in this concept as a manifestation, a kind indicators of status and changes in the fundamental substance $\rho$, $\varepsilon$, are deterministic (except for random fluctuations) measured (at least - for the F-mediums) givens. Therefore, experimentally determined physical coefficients / parameters / modules are usually dependent on $p$ and $T$, but in conditions of generally *global* equilibrium thermomechanical processes. Expressed the situation in Layfer (1954) called *e-conditions*. In connection with this there is realized in study Layfer (1954) procedure *inversion*, i.e. the transfer of the indicated coefficients, established in *e-conditions* the performance of the experiments, and the themselves functions $p$ and $T$ to *current* dynamic conditions of their expression through $\rho$, $\varepsilon$ in LTD QR. The starting point of this transition are: representation about the direct dependence of these parameters and functions only on the current values of $\rho$ (especially for gas) and $\varepsilon$, as well as the concept of *full* differentials and *curvilinear* integrals with introduction of the integrator factors (see (1) – (3) and also (Layfer, 1954)).

Note that in present work functions $p$ and $T$ essentially are considered as of *indicators* of the substances $\rho$ and $\varepsilon$ condition and change.

The main results of the made transformations are presented in the table relations (1) - (3), in which $\beta_\rho(\rho,\varepsilon)$ - the treatment function, and $\overset{\iota}{B}(\rho,\varepsilon)\wedge\overset{\iota}{G}(\rho,\varepsilon)$- volume and shear-modules of elasticity, their velocities and "accelerations" with convert from *e-conditions* of own experimental identification in conditions of the LTD QR according Layfer (1954). By similar inversions are subjects to modules $\overset{\iota}{R}$ and $\overset{\iota}{N}$ in operations (A). Detail of the further actions with indicated modules is considered also in article (Layfer, 1954).

It is clear, that possibly furthers amplification of ideas for physical coefficients by the inlet of its dependence in addition from substance $|\vec{v}|$ .

A. 7. *Direct* account rate of thermal deformation of the medium particles $\vec{v}_q$ as additive addition to the velocity $\vec{v}_f$ from the force fields, so that $\vec{v} = \vec{v}_f + \vec{v}_q$, is realized by the formula (5) where $\mathcal{A}$- is coefficient velocity of thermal deformations (see also (Morgunov, 2015a)) in the form of a product coefficients of conductivity of the temperature and linear thermal deformations.

A. 8. The author, as before, adheres to the opinion that for F-media, when critical parameters of a freely disturbed flow are reached, i.e. far from solid boundaries, a sporadic manifestation of a steep / abrupt / practically abrupt phenomenon occurs (one of the options due to the lack of experimental data) changes in the modula of deformation $\overset{\iota}{B}, \overset{\iota}{G}, \overset{\iota}{R}, \overset{\iota}{N}$, expressed in the form of turbulent monofurcation. In connection with the above, the postulate on the *dominant similarity* of the specified effect to the phenomenon of plastic deformation or brittle fracture in solid continuous media was advanced in Morgunov (2015a) (see also further the paragraph following relations (10a) and marked with a dot • on the left). However, unlike the mechanism for describing a turbulent transition, considered as a possible option, in Layfer (1954) with respect to the critical level of the main values of the deviator of the transposed strain velocity gradient tensor $\dot{\mathbf{S}}_d$, at this current stage of research, with permanent refinement and development of the present theory, it seems natural to propose a different, generalized criterion for *collapse transitions* in C-mediums, based on the property of *memory* about the pre-actual values of *e.m.p.* and written in the form of the following equality (10), obtained on the basis of the installations described in A.9.

The indicated development of the theory assumes: the nomination of the epistemological causal property of *reciprocity* of the left and right sides of the fundamental equations (I) - (IV) (see below), the establishment of an integral memory about the prehistory of particle deformation of the medium, the introduction of a *binary* $(L \wedge E)$ *reference system* and *viscous torsion* of the continuum moles with force elongation / shortening and rotation of their fibers / current tubes (Morgunov, 2015b), consideration of the problems of *near-wall interaction* Dryden (1959), *semi-analytically* established action factors Morgunov (2015b), Nikuradse (1933) etc.

A. 9. First of all we would bring in necessary clarifications for separate dependencies in the relations (6), (A), (B), (C) written down in *E-system* of counting of the right column table.

For fixed time moment $t + \partial\tau$ we would consider dyad $\vec{\nabla}_{\vec{\mathbf{x}}}\vec{a}_d = \left({\partial a_{dj}}/{\partial \mathbf{x}_i}\right)$ on *4D* scales next directly to the marked *e.p.m.* of its *prototypes.* Vector $\vec{a}_d$ is equal to difference $\vec{a}_d = \vec{a} - \vec{a}_c$, where vectors $\vec{a}$, $\vec{a}_c, \vec{a}_d$ are *pseudo*-accelerations $\partial\vec{v}/\partial t$, $\partial\vec{v}_c/\partial t$, $\partial\vec{v}_d/\partial t$ of the full velocity $\vec{v}$, forward motion $\vec{v}_c$ and *full distortion* $\vec{v}_d$ prototypes of the marked *e.p.m.* respectively. We think that focuses of these particles $\mathbf{c}_{L-s.p}$ for data interval/quantum of time $\partial\tau$ "passed" over some fixed points $\mathbf{c}_{E-s.}$ elementary volume $\mathbf{v}_E$ by *E-system*, accepted, in turn, in the capacity of centers (also focuses) $\mathbf{c}_{L-s.m}$ of the marked *e.p.m.* (particles)but in previous, on quantum smaller, moment of time, that is $\boldsymbol{t}$ (see Fig. 3 and also (6)).

The first part of the word *pseudo*-acceleration underlines fundamental difference of a classical notion about acceleration, as referred to unit mass measure of isolated body force of a inertia at action thereupon of the outside loading from appears above relations of differential proper velocities for two nearest *e.p.m.,* i.e. prototypes ← types, on vanishingly small distance from point $\mathbf{c}$ at to temporal equivalent $\partial t = \partial\tau$ of it deviation. Later on distinctive abbreviation *pseudo-* for foregoing vectors (in *E-system* analysis) we would be to omit, but word *acceleration* to enclose by upper double strokes ("acceleration") and for all partial differentials to make use symbol $\partial$.

For furthest it is important following circumstances.

1. At each fixed moment of time and for any point $\vec{\mathbf{x}} \in \bar{\mathbf{v}}$ of the volume of individually *e.p.m.* velocities of it transit transfer $\vec{v}_c$ have *equal* meaning, but in general depending from time and, consequently, from *current* coordinate of it focus $\boldsymbol{c}$ in space.

2. Later under terms "distortion/deformation" are regarded non-free changes of the value, form and elastic/viscid turning of some *e.p.m.*.

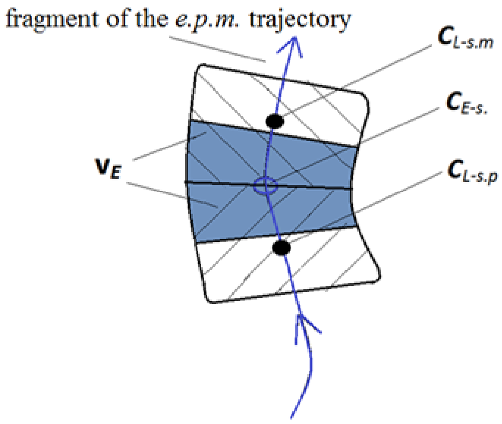


Figure 3: Conditional "image" of the *e.p.m.* passage across registration elementary volume $\mathbf{v}_E$ of the *Eulerian* space on the time interval of substitution $[t, t + \partial\tau]$. Here by fix $t$ and $t + \partial\tau$: $t < t < t + \partial\tau$.

As a result for stated above dyad we deduce (see also (B))

$$\vec{\nabla}_{\vec{\mathbf{x}}}\vec{a}_d = \vec{\nabla}_{\vec{\mathbf{x}}}\vec{a} - \vec{\nabla}_{\vec{\mathbf{x}}}\vec{a}_c = \vec{\nabla}_{\vec{\mathbf{x}}}\vec{a}. \tag{9$a$}$$

Present factor will be inserted and into vector/tensor operations. Thus, appearing further tensors of the convection carry $\mathbf{U}_c, \upsilon_c, \mathbf{a}_c$ for every fixed of the time moment and on *e.p.m.* scales are regarded as *tensor constants.*

Now we shall propose and discuss the criterion of the collapse-passage based on function of long memory accumulation (see (6) and further) about deformations of *e.p.m.,* it follows representative itself *a priori* considerable degree of probability.

Memory about *before the actual states* velocity $\vec{v}_d$ and proper deformation $\vec{u}_d$ in rigid $3D$ space and for start at rest $\vec{v}_{d.0} = \vec{u}_{d.0} = 0$ establishes by following integrals (in particular case of the start from state of the peace, see also and previously (6))

$$\vec{v}_d = \int\limits_0^t \vec{a}_d \partial\tau, \qquad \vec{u}_d = \int\limits_0^t (\int\limits_0^{\leftarrow t} \vec{a}_d \partial\tau)\partial\tau, \tag{9$b$}$$

where arrow between symbols of the integrals in (6) and (9b) means simultaneity of the their both increments at each subsequent time quantum.

On Fig. 4 is exemplified simplest, but visual example of the "memory effects" at discretely-linear change of the "acceleration" $\vec{a}_d$.

Let us remark here that structure of the integral representation for vector $\vec{u}_d$ excludes possibility of a permanent increase of *e.p.m.* deformations at $\vec{a}_d = 0$.

However expressions (9b) no permits without appearance "superfluous" unknowns to express change of deformations $\vec{u}_d$ during time across vector $\vec{a} = \partial\vec{v}/\partial t$ escaping "acceleration" $\vec{a}_c$ of the transit transfer *prototype* by marked *e.p.m.* over fixed point $\mathbf{c}$.

Thus we shall put forward following lower modification of the field of deformation $\vec{a}^{\bullet}_d, \vec{v}^{\bullet}_d, \vec{u}^{\bullet}_d$ taking off indicated above difficulty and with distinctive from previous notation as an point by the capacity of a superliner index.

Stated modification permits as we shall see later, formulate criterion of the collapse passage, i.e. metamorphosis, qualitatively changing character of a medium motion within the limits of solving detailed elaboration of dynamical processes of some $k$-th increment of *FWS*. Present phenomenon has at exceeding accumulated during time deformation in some point or into its totality of proper limiting level.

We shall represent in *E-system* modification of the "acceleration" deformations $\vec{a}^{\bullet}_d$ as it middling integral meaning by surface $\mathbf{s}$ of volume $\mathbf{v}$, conceding in each fixing moment of time

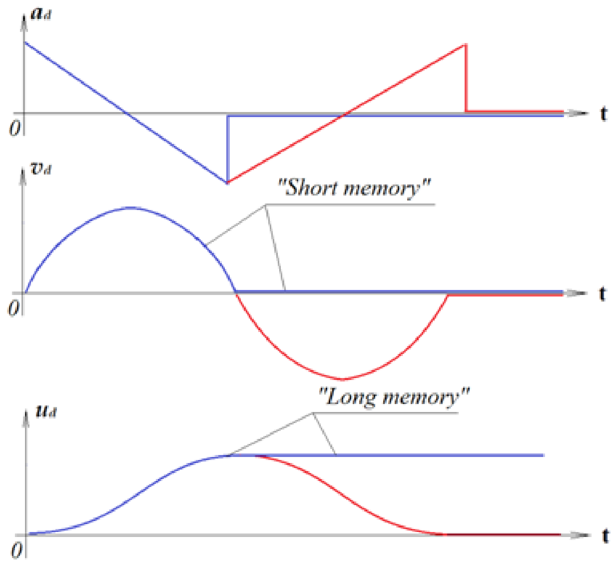


Figure 4: Didactic instance of the "memory effects" forming about *e.p.m.* deformation

with volume of the actual *e.p.m.* at additional referring of the present functions to typical linear scale $\boldsymbol{l}$. Then using known relations of the tensor analysis we obtain following the set of equality

$$\begin{aligned} \vec{a}_d^{\bullet} &= \frac{1}{l\mathbf{s}} \int\limits_{\mathbf{s}} (\vec{a}_d)_n \, \partial\mathbf{s} = \frac{1}{\mathbf{ls}} \int\limits_{\mathbf{s}} (\vec{n} \cdot \mathbf{a}_d) \partial\mathbf{s} = \frac{1}{\mathbf{ls}} \int\limits_{\mathbf{v}} \vec{\nabla}_{\vec{\mathbf{x}}} \cdot \mathbf{a}_d \partial\mathbf{v} \ni \\ \vec{a}_d^{\bullet} &= \frac{1}{\mathbf{ls}} \int\limits_{\mathbf{v}} \left( \vec{\nabla}_{\vec{\mathbf{x}}} \cdot \mathbf{a} - \underline{\vec{\nabla}_{\vec{\mathbf{x}}} \cdot \mathbf{a}_c} \right) \partial\mathbf{v} = \frac{1}{\mathbf{ls}} \int\limits_{\mathbf{v}} \vec{\nabla}_{\vec{\mathbf{x}}} \cdot \mathbf{a} \partial\mathbf{v}, \quad \vec{a}_d^{\bullet} = \vec{a}_d^{\bullet}/\mathbf{l} \ . \end{aligned} \tag{9c}$$

Here underlined item falls out.

In view of supposed continuity of functions, trifle spatial scales of *e.p.m.* and at convement choice $l = \mathbf{v}/\mathbf{s}$ (symbolical division in multitude theory) with admissible error, but with preference in simplicity, we shall find (on condition of use sign of the strong equality)

$$\vec{a}_d^{\bullet} = Div\ \mathbf{a} = \vec{\nabla}_{\vec{\mathbf{x}}} \cdot \mathbf{a}, \quad Dim\ \vec{a}_d^{\bullet} = c^{-2}. \tag{9d}$$

In (9c, 9d) $\vec{n}$ is singleness exterior normal to surface $\mathbf{s}$; $\mathbf{a} = (a_{ij})\,, \mathbf{a}_c = (a_{c.ij})\,, \mathbf{a}_d = (a_{d.ij})$ – *tensors* of the "accelerations" of velocities $\vec{v}$, $\vec{v}_c$, $\vec{v}_d$ *e.p.m.* transient across point $\mathbf{c}$; $Div \wedge Dim$ are reduction from words "divergence" and "dimension".

Similarly over divergence of the tensors of velocities $\mathbf{v}$ and transferences $\mathbf{U}$ is written vectors $\vec{v}_d^{\bullet}, \vec{u}_d^{\bullet}$ .

On integrating (9d) by $\boldsymbol{t}$ single (short memory) and twice (long memory) in view of expressed previously consideration with respect to expressions (9b) we shall establish

$$\begin{aligned} \vec{v}_d^{\bullet} &= \vec{\nabla}_{\vec{x}} \cdot v_d = \vec{\nabla}_{\vec{x}} \cdot v = \int\limits_0^t \vec{\nabla}_{\vec{x}} \cdot \mathbf{a} \partial\tau, \\ \vec{u}_d^{\bullet} &= \vec{\nabla}_{\vec{x}} \cdot \mathbf{U}_d = \vec{\nabla}_{\vec{x}} \cdot \mathbf{U} = \int\limits_0^t \left( \int\limits_0^{\leftarrow t} \vec{\nabla}_{\vec{x}} \cdot \mathbf{a} \partial\tau \right) \partial\tau. \end{aligned} \tag{9e}$$

It is possible second integral in (9e) consider in the capacity of modification of relative and averaged to $\mathbf{s}$ deformation of volume, form and turning of *e.p.m.* with centers are passing through point $\mathbf{c}$ at preservation memory about before the actual strained states of its particles of medium. Function of $\vec{u}_d^{\bullet}$ depends only on the components of tensor "accelerations" of surface distribution the desired vectors of velocity, i.e. specific momentum $(\vec{v})_n \in \mathbf{s} \Leftrightarrow \vec{n} \cdot (v_{ij})$.

In terms of adjusting supposition contained in following item marked from the left by points •, ••, •••, we shall accept that there is such limiting meaning $\left|\vec{u}_d^{\bullet}\right| = \bar{u}_d^{\bullet}$ at which appears collapse passage with sharp the drop of modules resistance by the motion of the *e.p.m.* Therefore, we shall propose following dimensionless criterion

$$I^* = \bar{u}_d^{\bullet}|^* = \left|\vec{\nabla}_{\vec{\mathbf{x}}} \cdot \mathbf{U}\right|^*, \quad Dim\, I^* = \emptyset, \;\; \mathbf{U} = (u_{ij}), \quad i \wedge j = \overline{1,3}\,. \tag{10}$$

To accomplish bringing in the most clarify to the subject under process underlined, that criterion (10), appearing also in relations (C) of the table, reduced to generally the vector $\vec{u}_d^{\bullet}$ by volume appearance of surface distribution virtual deformed location of points ***b*** (see Fig. 2). Process, certainly, is regarded in $3D$ for *E-system* and in time moments of passage also current (to formalism of *L-system* counting) *prototypes* by marked *e.p.m.* over as noted, some fixed point **c** of *Eulerian* space. The proper vector of the deformation is defined by scalar product of Hamilton operator $\vec{\nabla}_{\vec{\mathbf{x}}}$ (in *E-system*) and sum of tensors $\mathbf{U} = \mathbf{U}_A + \mathbf{U}_d$ by forward motion of noted *e.p.m.*, each *as unit* $\mathbf{U}_c$ and *full* deformations by its of the particles $\mathbf{U}_d$. Moreover by the preceding remark relatively of the equalities (9a) vector $\vec{\nabla}_{\vec{\mathbf{x}}} \cdot \mathbf{U}_c = 0$.

We shall indicate still yet, that in principle it is not inconceivable: alternative forming of the criterion passage on base first equality in expressions (9e) independently or in combination with criterion (10) at referring of vector $\vec{v}_d^{\bullet}$ to spectral velocity $v_{s.}$, established by limiting *FWN* certain $k$-th increment of *FWS*. Namely

$$\begin{aligned} &\vec{v}_d^{\bullet} = \omega_{s.}^{-1}(\vec{\nabla}_{\vec{x}} \cdot \upsilon), \upsilon = (\nu_{ij})\,, \omega_{s.} = æ_{s.}\nu_{s.}, \quad i \wedge j = \overline{1,3}, \\ &I^* = (b_u \bar{u}_d^{\bullet} + b_v \bar{\nu}_d^{\bullet})^*, \end{aligned} \tag{10a}$$

where $b_u, b_v$ are weight coefficients, $b_u + b_v = 1$.

We shall adduce some quality proofs / positive evidences in behalf of the present criterions.

• Reason from basics representations about material unity natural structure every concrete medium, satisfaction by it to fundamental laws of a thermomechanics, together with total character *direction* electromagnetic molecular and atomic interaction in present medium independently, however, from actual the kind of it*state of aggregation* of matter, represents permissible advancement postulate about *the dominant similarity* of plastic (or elastic-plastic or frail destruction) transition in solids and turbulent transition in fluids.

•• Numerous, long since, dubbed experiments for solids, by example, on one-axis tension prismatic samples either from constructive materials or brittle bodies, show that at deformation $\vec{u}_d$ proper to conditional limits of fluidity or of the extreme principal of the shear strain is taking place jump decrease of the modulus of volume elasticity and shear but in the latter case we have fragile destruction. Present fact can be treated as breakdown of increase intensity of the attraction property for intermolecular connections on its mediums. Then with this in mind contents of the previous item we assume *a priori* and in fact heuristically opinion about certain *correspondence* of the collapse-passage in C-mediums situated in various state of aggregation.

••• We shall omit enough laborious for concise description details of metamorphosis accompanying condition of the development of transitional processes in considered mediums we restrict only ascertaining of following. Structure relations (9e) and criterion (10) in its application to F-mediums permits qualitative, at least, explain face established also in distant years, but by careful the experiments, influence to origin of turbulence (in F-medium) heterogeneity by the enter stream at smooth solid boundaries but also apparently and view of a transitional process at a steady state. By consequence of the present circumstances is change of the critical Reynolds number in highly wide range of meaning $Re_{cr} \in [2 \cdot 10^3 \div 5 \cdot 10^4]$ and possibly more (see, for example Barnes & Coker (1905), Morgunov (2016), Morgunov (2016a), Monin & Yaglom (1965), Loitsyanskii (1978), Ozisik (1973), Morgunov (2017a) and etc.).

We shall indicate also, that relations (9c)-(9e), (10), (10a) involves *full* tensors displacement **U**, it velocity $\upsilon$ and "acceleration" **a**, but not its deviators, i.e. is taken into consideration and "spherical" part of *e.p.m.* volume deformation. Clearly, that only specifically posed physical experiments will be able bring clarity in present dilemma.

Besides, it remains open question, particularly important for *solid*, about equivalence (without take of sign) processes of a *tension* and *pressing* of medium filaments as approach it's to critical meaning.

To this and, we believe need to extract and explain two stated below and radically necessary important circumstances missing in work Nikuradse (1933).

* Property of a *concerted action* of the equations (I)-(IV) stated left and right parts assumes following.

Suppose, as and before, designation **f** is identifier one from the desired substances of a matter –field, so that $\mathbf{f} = \left\{\rho \vee \varepsilon \vee v_i \vee M_i, i = \overline{1,3}\right\}$ of everywhere dense set of points of some closed 3D *Eulerian* space $\overline{\mathrm{V}}$. In this domain $\overline{\mathrm{V}}$ we shall give a regular distribution of finite set counting quantity of the points $\vec{\mathbf{x}}_{rg}$ of a rigid *Eulerian* space. In each fixed moment of the time $t$=$\boldsymbol{t}$ we have also finite set, which is equal of the forgoing quantity, but the *labeled* points of the *trajectory Lagrangian* space with coordinates $\vec{x}(t) = \vec{\mathbf{x}}_{rg}$. In its points also at $t = \boldsymbol{t}$ are known all causal factors of the *action* to **f** (Nikuradse, 1933) in accordance to the left parts of the equations (I) - (IV). At change time in stated above scale for PP on quantum $\partial_\tau$ we will have

$$\vec{x}(t + \partial\tau) = \vec{\mathbf{x}}_{rg} + \vec{v}(\tau)\partial\tau = \vec{\mathbf{x}}_{ir}\,|_{t+\partial\tau}\,, t \leq \tau \leq (t + \partial\tau). \tag{11}$$

where $\vec{\mathbf{x}}_{ir}$- are the coordinates trajectory *irregular* points of their preceding regular set $\vec{\mathbf{x}}_{rg}$ but with functions **f** meanings

$$\mathbf{f} = \mathbf{f}(\vec{x}(t + \partial\tau), t + \partial\tau) = f(\vec{x}_{ir})\,|_{t+\partial\tau}\,.$$

Now let us denote by the symbol $\mathcal{LE}$ operator/algorithm of a reduction (from lat. *Reduction*-return to back) of a topological transfer, with inevitable and stipulated previously of physically objective *defect*, of functions **f** defined on set $\vec{\mathbf{x}}_{ir}$ as according to (11), from this set to set of formers fixed points $\vec{\mathbf{x}}_{rg}$. To result establishes the new (non-stationary state of the medium) values of this functions **f** are determined on regular *Eulerian* 3D grid $\vec{\mathbf{x}}_{rg}$ at time $\mathbf{t} + \delta\tau_k$ by equality

$$\mathcal{LE}\left\{\mathbf{f}(\overrightarrow{x}(t + \partial\tau), t + \partial\tau)\right\} = \mathbf{f}\left(\vec{\mathbf{x}}_{rg}\right)|_{t+\partial\tau} \tag{12}$$

At attainment of a steady state of the motion in the domain $\overline{V}$, beginning with $t = t^0 = \mathbf{t}^0$ clearly we obtain

$$\mathcal{LE}\left\{\mathbf{f}(\vec{x}_{ir}, t^0)\right\} = \mathcal{LE}\left\{\mathbf{f}\left(\vec{x}_{ir}, t^0 + m\partial\tau\right)\right\} = \mathbf{f}(\vec{\mathbf{x}}_{rg})|_{t^0},\ \ m = 1, 2, ....$$

with $\vec{x}_{ir} = \vec{x}(t + \partial\tau)$.

Particular case of the $\mathcal{LE}$ transformation is relevant to C-medium motion in filling of its immobile, closed and limited domain of a computation $\overline{\mathrm{V}}$= V∪S with fixed boundary S and taking into account at each next quantum of the time of the marked medium particles are intersected permeable fragments of boundary S with its ingress into domain $\overline{\mathrm{V}}$ or outcome from $\overline{\mathrm{V}}$. It is clear too that on basis of the conversional (12) are revived too corresponding functions of the *action* in left parts of the equations (I) – (IV) apart from its components which are not dependent directly from indicated earlier functions **f** (e.g. $\vec{q}_r$, possible $\vec{F}$).

**We shall pay attention yet to the following. Equation of a internal energy (increment) $\varepsilon$ (III) completely coincides which differential form of writing of the more total law about balance of full energy per unit time

$$\begin{gathered}\rho(\vec{F} \cdot \vec{v}) + \vec{\nabla}_{\vec{\mathbf{x}}} \cdot (\mathbf{\Pi} \cdot \vec{v}) + ((\vec{\nabla}_{\vec{\mathbf{x}}}\vec{u}_d)^* \times \mathbf{\Pi}) \cdot \vec{\Lambda} + \vec{\nabla}_{\vec{\mathbf{x}}} \cdot (\mathbf{M}^{(a)} \cdot \vec{\Lambda}) + \\ + \rho q_{cd} + \rho q_r = \frac{d}{dt}\rho\left(\frac{v^2}{2} + \varepsilon\right),\end{gathered} \tag{III'}$$

if velocity of change of a kinetic energy of a medium *macromotion* $v^2/2$ satisfies to expression

$$\rho\vec{F}\cdot\vec{v}+(\vec{\nabla}_{\vec{\mathbf{x}}}\cdot\mathbf{\Pi})\cdot\vec{v}=\frac{d}{dt}\rho\frac{v^2}{2} \tag{III''}$$

in which the left and right parts of this equation are written, as stated previously, in various systems of counting: $E\wedge L$.

The last demands of the additional analysis which is tied with question: whether justifies second term in expression (III") at left volume work per uniting of an exterior surface forces in *E-system*, i.e. at coordinates $(\overrightarrow{\mathbf{x}},\ \mathbf{t})$?

The term $\vec{\nabla}_{\vec{\mathbf{x}}}\cdot(\mathbf{\Pi}\cdot\overrightarrow{v})$ in (III') describes volume action of a work per unit time of exterior surface forces, one part of which goes into change of a kinetic energy of macroscopic motion $v^2/2$ of partices media. It motion is expressed of *phenomenological* by second term to left in equation (III").

The other part of scalar $\vec{\nabla}_{\vec{\mathbf{x}}}\cdot(\mathbf{\Pi}\cdot\overrightarrow{v})$ is directed into transformation of a internal energy $\varepsilon$. This part is defined in equation (III) of the first term at left. Let us remark, that by analogue of expression (III") in traditional model of thermomechanics C-mediums is equation which succeeds from relation (II) by means of the scalar product of it *both* parts on vector velocity $\overrightarrow{v}$, it is understood, only in *E-system* of counting.

Anyhow it's beyond question possibility of the inclusion in fundamental system (I)-(IV) equation (III') instead (III).

## 3 Supplements

Let us consider some particular simple models used for description of the fluid dynamics as examples of application of the proposed formalism with regarded that given conception contains group of the additional physical coefficients requiring of its determination. In considered examples $L\wedge E$ -systems of counting in essence fully are agreed upon.

### S.1. Main balance relations of the dynamics of ideal gas for barotropic processes with moderately inhomogeneous flow

In addition we accepts that thermomechanics is symmetrical and steady mass, processes are stationeries and to be considered along of the flow lines. Conditions stipulated in the title of this subsection and followings imply that operator $\frac{d}{dt}=\overrightarrow{v}\cdot\overrightarrow{\nabla}_{\vec{\mathbf{x}}}\ni d\overrightarrow{\mathbf{x}}=d\overrightarrow{x}$, tensor $\mathbf{\Pi}$=$\mathbf{P}_s=p\cdot\mathbf{I}$, $\overset{\iota}{G}=0,\dot{B}\approx\ddot{B}\approx 0$ and in fact we proceed to the notions of quasi-equilibrium thermodynamics. Further subscript at operator $\overrightarrow{\nabla}$ is lowered.

As known, the equation of energy balance per unit time for a continuous medium in full writing and for a given case (see too (III')) is as follows:

$$\rho\frac{d}{dt}\left(\varepsilon+\frac{v^2}{2}\right)=\rho\vec{F}\cdot\vec{v}+\vec{\nabla}\cdot(\mathbf{P}_s\cdot\vec{v})+\rho q,\quad q=q_{cd}+q_r. \tag{13}$$

This equation reduces to balance relation (III) upon subtraction of an equation of energy balance for macroscopic motion, which is obtained by scalar multiplication of both parts of relation (II) by velocity $\vec{v}$.

Setting $\rho=\rho(p)$ and using Eqs. (III),(2) (see Table) at $\mathbf{k}=1$ and (13) in the theoretical model under consideration and taking into account that the initial pressure is equal to the algebraic sum of lower limits of integration in expression (2), we obtain the following equations for the class of barotropic flows.

$$\frac{d}{dt}\left(\varepsilon+\frac{v^2}{2}\right)=-\vec{v}\cdot\vec{\nabla}\Pi-\frac{1}{\rho}\vec{\nabla}\cdot(p\vec{v})+q,\quad \frac{1}{\rho}\vec{\nabla}\cdot(p\vec{v})=\vec{v}\cdot\frac{\vec{\nabla}p}{\rho}+\frac{p}{\rho}\vec{\nabla}\cdot\vec{v}, \tag{14}$$

$$\vec{v}\frac{\vec{\nabla}p}{\rho} = \vec{v}\cdot\vec{\nabla}\mathcal{P}(p(\rho,T(\rho))), \quad \frac{p}{\rho}\vec{\nabla}\cdot\vec{v} = -\frac{p}{\rho^2}\frac{d\rho}{dt}, \tag{14a}$$

$$\frac{d}{dt}\varepsilon - \frac{1}{\rho}\mathbf{P}_S\cdot\cdot\dot{\mathbf{S}} + q = -\frac{p}{\rho}\vec{\nabla}\cdot\vec{v} + q \;\ni\; \frac{d}{dt}\frac{v^2}{2} = -\vec{v}\cdot\vec{\nabla}\Pi - \vec{v}\cdot\vec{\nabla}\mathcal{P}, \tag{14b}$$

which naturally yield the well-known generalization of the Bernoulli equation for steady-state regime of motion along the flow lines:

$$\frac{v^2}{2} + \mathcal{P} + \mathbf{\Pi} = constP, \quad \mathcal{P} = \int\frac{dp}{\rho}, \tag{15}$$

where $\mathbf{\Pi}$ is the potential of mass forces, $\mathcal{P}$ is the pressure function that is assumed to depends on $\rho$ and $T$ is assumed to be a function of $\rho$.

For the ideal gas we obtain the following relations (here and below, subscripts $T$ and $\rho$ at partial derivatives are omitted):

$$dp = \frac{\partial p}{\partial\rho}d\rho + \frac{\partial p}{\partial T}dT = \frac{B}{\rho}d\rho + \frac{B_\rho}{T}dT. \tag{16}$$

The latter sum is actually a complete differential of pressure, provided that $B/\rho = RT$ and $B\rho/T = R\rho,$ where $R = const.$ Therefore, $B\rho = B$ and, if these module are equal to pressure $p$ (i.e., to isothermal value of the bulk elastic modulus), we arrive at a formula that coincides with the Clapeyron equation, while the differential of pressure $p$can be expressed as

$$dp = R\, d(\rho T). \tag{17}$$

In application to polytrophic processes, which constitute a broad subclass of barotropic processes, the relation $dp = n\,(p/\rho)\,d\rho$ is valid provided that $T = ({}^{T_0}\!/_{\rho_0^{n-1}})\rho^{n-1}$ in relation (16). In this case, $Bn = np$ is a bulk elastic modulus in the given dynamic process.

In the case of adiabatic flows, i.e., for $q = 0$, it follows from Eqs. (14)-(14b) and (16) that

$$d\varepsilon = RT\rho^{-1}d\rho = d\hat{i} - d\frac{p}{\rho} = d\hat{i} - \frac{dp}{\rho} + \frac{p}{\rho}\rho^{-1}d\rho = d\hat{i} - d\mathcal{P} + RT\rho^{-1}d\rho,$$

where $\hat{i}$ is enthalpy. Therefore, $d\hat{i} = d\mathcal{P}$ and Eq. (15) can be written in the following quasi-equivalent form.

$$\frac{v^2}{2} + \hat{i} + \Pi = const_{\hat{i}} \tag{18}$$

so that energy balance trinomial (18) differs from (15) by a constant. Then, using Mayer's formula $R = c_p - c_v$, we obtain

$$d\varepsilon = c_{\mathrm{v}}dT = RT\rho^{-1}d\rho \quad \ni \quad d\ln T = (k-1)d\ln\rho \;\ni\; \frac{T}{T_0} = \left(\frac{\rho}{\rho_0}\right)^{k-1}, k = {}^{c_p}\!/_{c_{\mathrm{v}}}.$$

Using these relations and the Clapeyron equation, we eventually arrive at the classical Poisson's adiabatic equation, $p/\rho k = const.$ In the presence of external heat supply, $dq = Td\hat{e}$, where $d\hat{e}$ is increment of an entropy, we readily obtain the well-known formula

$$d\hat{e} = c_{\mathrm{v}}d\ln{}^{p}\!\big/_{\rho^k}, \tag{19}$$

which shows that for $d\ln(p/\rho k) = 0$ in Eq. (19) (i.e., for $dq = 0$), the adiabatic flows of ideal gases are isentropic.

Thus, the formalism developed in this work, when applied to a particular case of gas flow (which is widely used in solving many practical problems) is fully consistent with the corresponding field of gasdynamics.

**S.2. Steady-state laminar flow of a fluid in a cylindrical round tube with smooth walls at $T = const$**

Conditions stipulated in the title of this subsection imply that we can set

$$v_z = v_z(z, r),\ v_\varphi = 0,\ \dot{B} \approx \ddot{B} \approx G \approx \ddot{G} \approx 0,\ B = B(z),\ \rho^{-1}\dot{G} = \rho^{-1}\mu = \upsilon = const.$$

Besides, restriction accepted in example S.1 also are maintained but at $\dot{G} \neq 0$.

In this case, it is natural to use a cylindrical coordinate system ($r$, $\varphi$, $z$), where $z$ is measured along the tube axis as indicated on Fig.5a. Assuming in addition that the radial component $v_r$ of velocity $\vec{v}$ is negligibly small, the pressure and density will depend only on the axial coordinate: $z \ni p = p(z), \rho = \rho(z)$. This assumption poses rather strict limitations on the algorithm of solution of this problem.

In the given particular case, the equations of continuity (I) and momentum balance (II) reduce to the following relations

$$M(r) = \rho(z)v_z(r, z) \quad \ni \quad v_z = \frac{\rho_0}{\rho(z)}v(r), \tag{20}$$

$$\mu(\frac{\partial^2 v_z}{\partial r^2} + \frac{1}{r}\frac{\partial v_z}{\partial r} + \frac{\partial^2 v_z}{\partial z^2}) - \rho v_z \frac{\partial v_z}{\partial z} = B\frac{1}{\rho}\frac{d\rho}{dz}, \tag{21}$$

where $M$ is the mass flow rate [kg/(m2 s)] that depends only on $r, \rho_0$ is the density in the input cross section where the fluid flow enters the tube. It follows from Eq. (20) that $v_z$ is described by an expression with separable variables.

Analysis shows that, for the low-gradient (layered) flow under consideration, the last term in parentheses on the left-hand side of Eq. (21) can be ignored and, for the existence of a single solution, it is necessary to set the values of pressure $p_0, p_1$ in cross sections $0-0$ and $1-1$ (fluid in- and outflow, respectively) and function $\rho(z)$ and to transform relation (21) into an ordinary differential equation with constant coefficients for the unknown function $v(r)$.

Omitting the description of simple transformations and passing to dimensionless variables, we eventually obtain from Eqs. (20) and (21) (see also Fig. 5a) the following relations:

$$\begin{gathered}\frac{d^2\bar{v}}{d\bar{r}^2} + \frac{1}{\bar{r}}\frac{d\bar{v}}{d\bar{r}} + R_1(\bar{z})\bar{v}^2 = R_2(\bar{z}),\quad R_1 = \frac{r_0^2 v_0}{l\upsilon}\frac{1}{\bar{\rho}^2}\frac{d\bar{\rho}}{d\bar{z}},\ R_2 = \ -\frac{4}{\ln\bar{\rho}_1}\ \frac{1}{\bar{\rho}}\frac{d\bar{\rho}}{d\bar{z}},\\ \bar{v} = \frac{v}{v_0},\ \ v_0 = -\frac{r_0^2}{4\rho_0\upsilon}\frac{\Delta p}{l},\ \ \Delta p = p_1 - p_0,\\ \bar{r} = \frac{r}{r_0},\ \ \bar{z} = \frac{z}{l},\ \ \bar{\rho} = \frac{\rho}{\rho_0},\ \ \rho_1 = \exp(\Delta p/B),\end{gathered} \tag{22}$$

where the characteristic velocity $v_0$ corresponds to the maximum value on the paraboloid profile of velocity according to the model of incompressible fluid.

Restricting the consideration to a linear approximation for the fluid density $\bar{\rho} = 1 + \Delta\bar{\rho}\ \bar{z}, \Delta\bar{\rho} = \bar{\rho}_1 - 1$, multiplying both parts of Eq. (22) by *dz,* and integrating over $\bar{z} \in [0, 1]$, we eventually obtain the following ordinary nonlinear differential equation:

$$\frac{d^2\bar{v}}{d\bar{r}^2} + \frac{1}{\bar{r}}\frac{d\bar{v}}{d\bar{r}} + \bar{R}\bar{v}^2 = -4,\ \ \bar{R} = -\frac{r_0^4\,\Delta p}{4\upsilon^2\rho_0 l^2}\ \frac{\Delta\bar{\rho}_1}{\bar{\rho}},\ \ \bar{v}_z = \bar{\rho}^{-1}\bar{v}. \tag{23}$$

Evidently, in the model of incompressible fluid $\bar{\rho}_1 = 1 \wedge \Delta\bar{\rho}_1 = 0 \ni \bar{R} = 0$ and a solution of Eq. (23) corresponds to the classical *Poiseuille* velocity profile $\bar{v}_z = \bar{v} = 1 - \bar{r}^2$, representing a paraboloid of rotation.

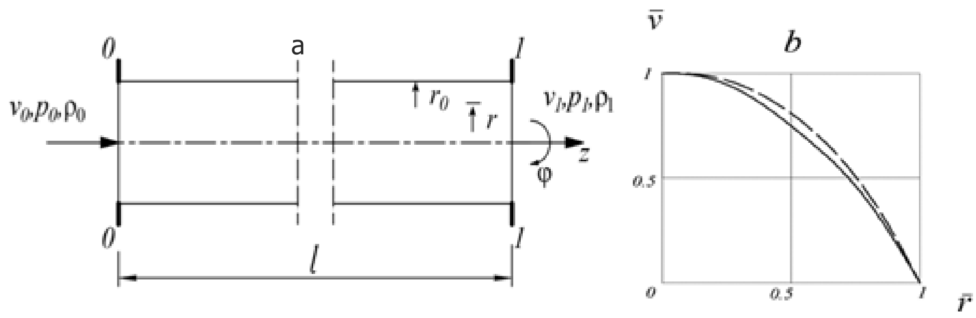


Figure 5: Fragment of the tube and dimensionless of velocity $\bar{v}(\bar{r})$ epures

Numerical solutions of Eq. (23) for liquids showed that, in the interval of pressure changes $\Delta p$ corresponding to Re values in the field of laminar flow regimes, the effect of compressibility described by the term $\bar{R}\,\bar{v}^2$ is negligibly small. An analogous conclusion is valid for isothermal layered flows under conditions of normal and rarefied gases. As it was expected, the effect of compressibility, manifested by a significant difference of the velocity $\bar{v}_z$ from its *Poiseuille* profile, is observed only for strongly rarefied gases. Fig.5b (solid curve) shows of the dimensionless *Poiseuille* velocity profile. Dashed curve shows the results of calculation using Eq. (23) for the following parameters: $r_0 = 5 \cdot 10^{-3}m, l = 1m, B = 60550Pa, \rho_0 = 0.8kg/m^3, \upsilon = 1.5 \cdot 10^{-5}m^2/s, \Delta p = 230Pa, Re = 4 \cdot 10^4$ and $\bar{R} = -0.76$. In this case $\bar{z} = 1$ and velocity is displayed to it meaning on the tube axis. As can be seen, differences between the two velocity $\bar{v}$ distributions are relatively small, although the Re value adopted in calculations corresponds in fact to a turbulent flow regime.

## S.3. One-dimensional stationary isothermal efflux of the ideal liquid via a nondivergent nozzle

With a view to obtaining only a qualitative picture, let us consider a simple model with modulus $B$ set to be constant (in particular, let fluid to be water with $B = 2.25 \cdot 10^3 MPa$). Fig. 6a shows a model scheme used in calculations. Spacer $l$ separates two reservoirs (the left-hand one being of large volume), so that liquid can flow from left to right only via a hole with hermetically mounted nozzle *2*, provided that $\rho_1 < \rho_0$. The density $\rho_0$ and pressure $p_0$ in some inlet cross section $0-0$ (sufficiently far from the left input edge of the nozzle) represent the "retardation" parameters $v_0 = 0$). Cross sections $i-i$ and $l-l$ correspond to the right-hand boundary of the initial region with constant steady-state flow velocity $v$ and the nozzle output section, respectively.

With neglect of mass forces, assuming small radial dimensions of the nozzle, Eq. (24) yields

$$\mathcal{P} = B\int \frac{d\ln\rho}{\rho} \quad \ni \quad \frac{v^2}{2} - \frac{B}{\rho_1} = -\frac{B}{\rho_0} \quad \ni \quad v = \sqrt{2B(\rho_1^{-1} - \rho_0^{-1})} \tag{24a}$$

or with allowance for a physical result

$$v^2 - \frac{2B}{M}v + \frac{2B}{\rho_0} = 0 \quad \ni \quad v = \frac{B}{M} - \frac{1}{2}\sqrt{\frac{B^2}{M^2} - \frac{2B}{\rho_0}}, \tag{24b}$$

where $M$ is the mass flow rate. For $\rho_0 = const$ and decreasing density $\rho_1$ (and, hence, pressure $p_1$, since $p_1 - p_0 = B\ln\frac{\rho_1}{\rho_0}$) from $\rho_0$ to $\rho_1^* = \frac{\rho_0}{2}$, the flow velocity in the right-hand reservoir reaches a critical value of $v^* = \sqrt{\frac{2B}{\rho_0}} = \sqrt{\frac{B}{\rho_1^*}}$ with the well-known phenomenon of efflux blocking. For water under conditions close to normal with $\rho_1^* = 10^3 kg/m^3$ and $p_1^* = 10^5 Pa$, the flow considered from the abstract point of view (i.e., without a change in the physical state of medium and its flowability properties) will proceed purely theoretically for $\rho_0 = 2{\cdot}10^3 kg/m^3$ and $p_0 \approx 1560MPa$ at the efflux with a sound velocity of $v^* = 1500m/s$.

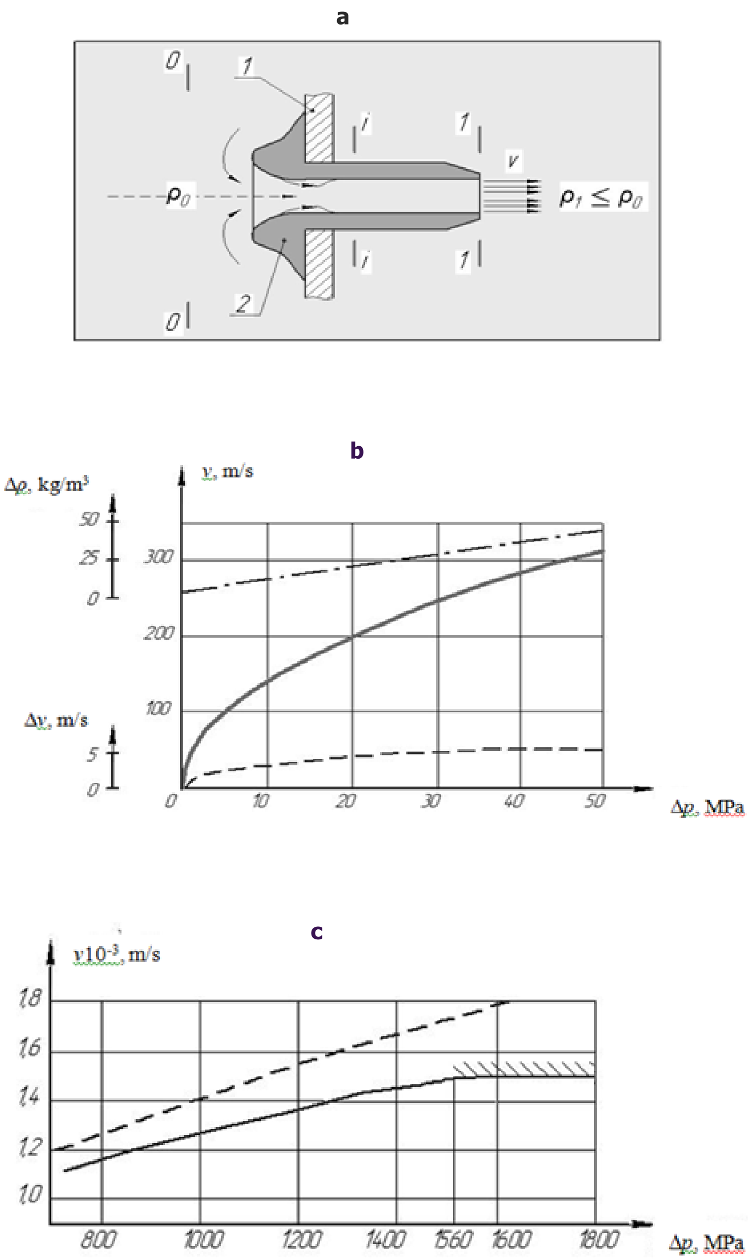


Figure 6: Qualitative estimation of compressibility effect on velocity of fluid outflow from hydraulic nozzle

Fig. 6b shows the plot of flow velocity $v$ versus $\Delta p = p_0 - p_1$ (in the interval of practically significant variation of this parameter) in steady-state regimes in cross section $1-1$, calculated using the proposed model with allowance for compressibility (solid curve), which almost coincides with the velocity profile according to the model of incompressible liquid. The dashed curve shows the excess velocity $\Delta v$ according to the latter model (plotted on a greater scale), while the dash-dot curve represents the corresponding excess density $\Delta\rho = \rho_0 - \rho_1$.

Fig. 6c shows the analogous plots of velocity $v$ for the models of compressible (solid curve) and incompressible (dashed curve) liquids in the vicinity of a hypothetical zone of efflux blocking. As can be seen, a significant difference of velocity $v$ for the two theoretical models under comparison is only observed at very large pressure differences $\Delta p$, which are difficult or even impossible to achieve in practice. These results exhibit positive correlation with a conclusion made in the preceding subsection S.2 concerning a negligibly small influence of the compressibility of fluids on the dynamic process in steady-state layered flows. However, it is hardly possible that this conclusion can also be expanded to turbulent flows, which are principally three-dimensional and non-stationary and (according to both theoretical and experimental data (Ekman, 1911)) have derivatives with respect to $(\vec{x}, t)$ that exceed by many orders of magnitude the values taking place in laminar regimes of fluid motion.

# 4 Conclusion

1. Worked out the foundations of the non sacramental theory of continuous mediums thermomechanics.

2. Obtained new phenomenological closed system of equations for strongly indignant dynamics of these mediums. The unknown functions are the fundamental substances of the matter-field: the specific mass $\rho$, the momentum $\vec{v}$, the increase of internal energy $\varepsilon$, - and also *direct turn* of the marked *e.p.m.* for unit of time $\vec{\Lambda}$, determining the inertial moment at it appearance in the course of viscous turnings of the real C-mediums elementary particles.

3. Unfortunately, a large group of physical coefficients / parameters / indicators with qualitatively different weighting contributions to balance equations for yielding deformation C-mediums and being in various of aggregate conditions requires its experienced pre-definition, and essentially - the initial establishment. Therefore, it can be assumed that the article is oriented *on the future* and at professionals, theoreticians and experimentalists which are working creatively in the field of research strongly perturbed dynamics of continuous media in nature and artifact of various purposes, including energy machines and other thermo-, hydro-, and gas- power plants.

**Notations**[1]

$\vec{F}$ - vector by volume forces;

$\overset{\iota}{\underset{d}{\mathbf{S}}}$ - deviators of the symmetric transposed tensors for gradients:deformations $\mathbf{S}\left(\frac{d\vec{u}_d}{d\vec{\mathbf{x}}}\right)^*$, their velocities $\dot{\mathbf{S}}\left(\frac{d\vec{v}_d}{d\vec{\mathbf{x}}}\right)^*$ and *pseudo*-accelerations (or simple "accelerations") $\ddot{\mathbf{S}}\left(\frac{d\vec{a}_d}{d\vec{\mathbf{x}}}\right)^*$;

$\overset{\iota}{B}$, $\overset{\iota}{G}$,$\overset{\iota}{R}$ and $\overset{\iota}{N}$– modules of deformations of volume and shears ($\iota = \emptyset$), its velocity $\iota = \bullet$, "acceleration" $\iota = \bullet\bullet$) from strain tensors $\mathbf{P}_s$,$\mathbf{P}_d$, $\mathbf{P}^{(a)}$ and moment of strain $\mathbf{M}^{(a)}$ accordingly;

$\mathbf{I}$, $\mathbf{1}$ - the unit tensor and the Heaviside step function;

$\xi$– for F-mediums is distance by strong interaction with wall, or with boundary surface of two-phases jets mixing;

$I_x$ -index of a binary interacting (see also [8]);

$c_v$ - specific heat at constant volume;

$\mathbf{J}, c_j, æ_j$ - moment of inertia; coefficient of correction and the weighted mean wave number characterizing the local spatial topology of the marked *e.p.m.* by normal to direction of $\vec{\Lambda}$;

$\vec{\Lambda}$ -vector of turn of the marked *e.p.m.* for unit of time (parameters $c_J, æ_J$ need in special analysis);

$\vec{q}_{cd}, \vec{q}_r$ - vectors of conductive and radiation heat transfer;

$\vec{u}_d$, $\vec{v}_d$, $\vec{a}_d$- vectors of deformation, it velocity and "acceleration" from removal and rotation shears in *E-system* counting; second word-to-word index 0 marks the initial conditions;

$\overset{\iota}{\vec{w}}, \overset{\iota}{\vec{w}}_d$ - additional vectors that simplify the formulas; $\overset{\iota}{\vec{w}}_c$– the proper referring to forward motion of *e.p.m.*;

$\lambda$ - heat conductivity coefficient; $\mu$ - dynamic viscosity coefficient;

$\mu_\beta, \overset{\iota}{\mu}_b, \overset{\iota}{\mu}_g$ – integrator factors;

[1]mainly not explained into text

$I^*$- criterion in relations (C) meets to increment of wave specters with modulus of the wave number æ$_s$;

$\vec{u}_d^{\bullet}, \bar{u}_d^{\bullet}$- modifications of the vector of deformation and its modulus related to linear scale $\mathbf{l} =$ æ$_{s.}^{-1}$;

$\mathbf{U} = [u_{ij}]\,,\ v = [v_{ij}]\,, \mathbf{a} = [a_{ij}]\,,\ \ i \wedge j = \overline{1,3}$ - *tensors* of the removal, in quantum of time, it velocity, “acceleration”;

*si, eo, et., ubi, ad, edo, ut lex, vel, solid media, liber/iunetus turbulences* - from Lat. designations: ”if”, ”then”, ”and”, ”where”, ”when”, ”since”, ”usually”, ”or”, ”solid medium”, ”free/constrained turbulence respectively”;

$\bullet, \bullet\bullet, \times$ - scalar, biscalar, vector products;

$\vec{\nabla}_{\vec{\mathbf{x}}}$– operator of Hamilton in *E-system* of counting;

$\wedge, \vee, \bigcup, \ni, \in, \emptyset,$ - logical ”and”, ”or”, ”union”, ”so”,”belongs”, ”empty set”.

*e.p.m.*, *FWS*, *FWN* – elementary particle of medium, frequency-wave spectrums / numbers of its *e.p.m.*.

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